

OPERATIONAL APPLICATION

Standard and Research of Home Network

Ao Li

(The Communications Standard Research Institute, CATR, MII, Beijing 100083, China)

Abstract:

With the continuous development of a home network, the Consumer Electronics (CE)/IT industry has different understanding and developing thoughts from telecommunications industry. Several international and domestic organizations are actively engaged in formulating home network standards. Nowadays, the relevant standards are not unified. In China, there are three main organizations involved in home network standards: the Intelligent Grouping and Resource Sharing (IGRS) working group, ITopHome, and China Communications Standards Association (CCSA). They have made some achievements on standardization research. In order to strengthen ability of independent innovation in home network area and speed up the progress of standardization, the three organizations must break through the industrial barrier, intensify cooperation and make full use of complementary advantages to research China's proprietary standards for home networks with a win-win attitude.

1 Different Understanding of Home Network

The proposal of the home network concept involves telecom, Consumer Electronics (CE), and IT industry. These industries have different understanding of the home network.

1.1 The CE/IT Industry

The concept of home network is initially proposed by the CE/IT industry. The home network refers to an integrated home information platform, converging home control networks and multimedia information networks. It implements interoperability and manageability functions among devices in the home. The devices include but are not limited to information devices, communication devices, entertainment devices, household electric appliances, automation devices, lighting devices, security (supervision) devices, home emergency call and alarm devices, and

meters to measure water, electricity, gas and heat. Meanwhile, it establishes a system to share data and multimedia information. The main purpose of a home network is to break various "information isolated islands" and realize resource sharing and cooperation among information, communication and consumer electronic devices at home or office.

Presently, main applications of home networks cover the following aspects.

- Personal Computer (PC) is interconnected with home storage devices, printers and other peripheral equipment to enable resources sharing.
- Movie, music, amusement and other household electric appliances share cooperative services, for example, to transmit and share multimedia information through TV, stereo set, DVD, computer and other multimedia devices.
- CE is controlled by network, for example, lighting and air-condition.

1.2 The Telecommunications Industry

The concept of home network proposed

by the telecommunications industry has the following meanings.

- The home network is not only a network technology, but also a kind of service.
- The home network must be connected with a telecommunications network. Indeed, it is even a part of an end-to-end telecommunications network. With a home gateway, it is possible to extend public network functions and applications to home.
- The home network can provide and bear multiple services, including integrated voice, data, multimedia, high quality of audio and video, control, and management services.

Currently, when operators mention a home network, they particularly emphasize on "telecommunications network/Internet-based, home-oriented multiple services" and stress the concept of "home gateway". The meaning of "resource sharing and service cooperation among in-home terminals" as proposed by the CE/IT industry is not obvious in the understanding of the

telecommunications industry. Therefore, the telecommunications industry has a different understanding of "home network" from the CE/IT industry.

2 International Standardization Organizations for Home Network

Several international organizations are involved in the standardization of the home network. These organizations are divided into two categories: telecommunications industry organizations and CE/IT industry organizations, where the International Telecommunication Union Telecommunication Standardization Sector (ITU-T) and Universal Plug and Play (UPnP) are two typical organizations.

2.1 ITU-T

Since ITU-T is dedicated to telecommunications standards, its home networking research covers the content of connectivity with public networks. Nowadays, ITU-T pays increasing attentions to the home network. ITU-T made an initial plan to carry out some standardization activities of the home network after an internal seminar in July 2005. At the same time, a Joint Coordination Activity on Home Networking (JCA-HN) was established, aiming at the home networking standardization research. From the view of ITU-T, the home network is the last segment of an end-to-end telecommunications network. Hence, how to plan, define, and regulate the last segment of a network to eventually provide multiple telecommunication services is the main purpose of ITU-T in the area of home network. For this reason, the ITU-T home network working group puts much efforts in the research

of home gateway centered network architecture, Quality of Service (QoS), home network security technologies and relevant telecommunications services. However, other contents such as the in-home device connectivity and content sharing as covered by home entertainment technologies are not studied by ITU-T, let alone relatively independent technologies like in-home automation and control.

2.2 DLNA/UPnP

The Digital Living Network Alliance (DLNA), formerly called the Digital Home Working Group (DHWG), established in June 2003, is a cross-industry organization, and its activities involve CE, PCs, and mobile device companies. Many DLNA activities are highly associated to another standardization organization, called UPnP in term of the technical standard. Indeed, both organizations have very close relationship. The vision of DLNA/UPnP is to construct a wired and wireless interoperable network, consisting of PCs, CE, and mobile devices at home. The network will provide a seamless environment to share and grow new digital media and content services. The research contents of DLNA standardization mainly include connectivity among devices at home so that customers can share contents and enjoy movie, music, and amusement. Thereby, DLNA/UPnP does not have the same goal and research area as ITU-T. Both research areas form a complementary relationship.

3 Situations of Relevant Standardization Organizations in China

In China, three domestic organizations are involved in formulating home network

standards: the Intelligent Grouping & Resource Sharing (IGRS) working group, the ITopHome and the China Communications Standards Association (CCSA). The IGRS and ITopHome are formed with some CE/IT manufacturers while members of the CCSA home network working group are from institutes, operators, and manufacturers in the telecommunications industry. To date, three organizations have made some research achievements.

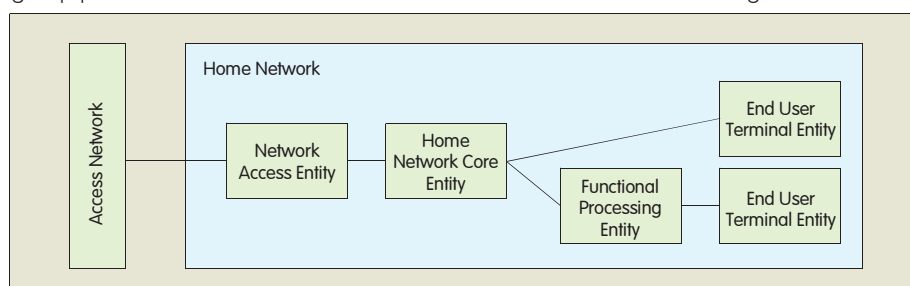
According to bandwidth requirements for a home network to transmit information, home network services and applications may be classified into two categories: information services that required high-bandwidth and control services that required low-bandwidth. The information services that required high-bandwidth can be further divided into in-home information sharing services and public network provided information services.

By reviewing the research achievements, we find that IGRS and ITopHome mainly focus on in-home information sharing services and control services that required low-bandwidth. The two organizations are quite compatible to DLNA/UPnP in research focuses on the connectivity among CE, PCs, and mobile devices. However, the CCSA home network working group is more concentrated in home-oriented communication services provided by the public telecommunications network, which is quite compatible to ITU-T as it particularly covers telecommunications equipment. Again, we draw a conclusion that the three domestic organizations are well complemented in the standardization work with each other having distinct advantages.

4 The Home Network Reference Model and the Home Gateway Based on the Telecommunications Network

4.1 The Home Network Reference Model

Figure 1 shows the home network reference model, based on the telecommunications network. The home network consists of four logical functional



▲ Figure 1. The home network reference model.

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entities as described below:

- Network Access Entity (NAE) is responsible for terminating access.
- Home Core Entity (HCE) is responsible for core functions of a home network, including connectivity among in-home devices, remote management, QoS, security, and more.
- Functional Processing Entity (FPE) is responsible for the IP/non-IP conversion as well as the signalling and media format conversion.
- End User Terminal Entity (EUTE) provides User Interface (UI) for end users.

Physical devices in a home network may be divided into four types: access terminal, home gateway, adapter, and end user terminal.

An access terminal implements the NAE function, for example, the Asymmetric Digital Subscriber Line (ADSL) Modem is one of the numerous access terminals. A home gateway implements the combination functions of logical functional entities, probably being HCE, HCE+FPE, NAE+HCE, or NAE+HCE+FPE. An adapter implements the FPE function. For example, the IPTV set-top box is an adapter.

If a home network is built based on the telecommunications networks, the following functions should be supported in order to extent multiple telecommunications services and applications into home.

(1) The Capability to Connect to the Telecommunications Network

The home network may adopt various access modes to connect to the telecommunications network.

(2) The Capability to Interconnect In-home Devices

The connectivity technology adopted by in-home devices should have a certain scalability to meet the needs of service development. The selection of in-home connectivity technology should consider service requirements for the bandwidth, QoS and the transport distance. If wireless connectivity technology is adopted, the air-interface security must be noticed.

(3) The Device Management Capability

The home network devices may be managed locally or remotely. On one hand, home network devices should

provide the local management interface to support login, management, and control functions locally. This management interface is only available locally, that means, it can not be accessed outside the home. On the other hand, relevant home network devices (such as home gateways, set-top boxes, and others) should support remote management functions so that operators can manage them either directly or through the agency of a home gateway. When home network devices support remote management functions, a certain level of security must be considered to avoid illegal management. Either TR069 or Simple Network Management Protocol (SNMP) may be adopted as the remote management protocol.

(4) The QoS Capability

The QoS assurance technology in the home network should be able to classify services and applications by priority. The end-to-end transport ability must be guaranteed to meet service network requirements. To achieve it, bandwidth and priority of services and applications must be adjustable according to different requirements from users or management systems. Meanwhile, the QoS assurance technology in the home network must support interoperability and coordination with the QoS technology adopted in telecommunications networks, and must be compatible to various home access technologies and in-home connectivity technologies. Furthermore, the QoS assurance technology must have QoS monitoring and statistics capabilities as well.

(5) The Security Capability

The home network should ensure the security of home network devices and the safe information transmission.

(6) The Device Auto-discovery Capability

To implement auto-discovery and auto-configuration functions across in-home devices, devices should abide by the SJ/T 11310 *Information Device Resource Sharing and Cooperative Services Part One: Basic Protocols* or UPnP UDA 1.0 *UPnP™ Device Architecture*.

(7) The Service Processing Capability

The home network not only is a service-bearing network, but also has service processing capabilities, such as

VoIP or IPTV service processing.

(8) The Service Providing Capability

The home network should allow permitted remote users to access it from outside, and provide service capabilities, such as video monitoring, appliance information for remote control, and home website.

(9) The Power Supply Capability

If a home network supports a special service, which requires uninterrupted power supply, the relevant device must have battery or the remote power supply function to meet this special need.

(10) Scalability

Since new services will be introduced continuously, the home network must have scalability to support them.

4.2 Home Gateway

4.2.1 Definition and Classification of Home Gateway

A home gateway is a device connecting the home networks and the telecommunications networks. Through the home gateway can information be communicated between home network devices and telecommunications networks, or between home network devices.

For a home gateway, the possible combination of logical functional entities may be: HCE, HCE+FPE, NAE+HCE, or NAE+HCE+FPE. This article recommends NAE+HCE or NAE+HCE+FPE.

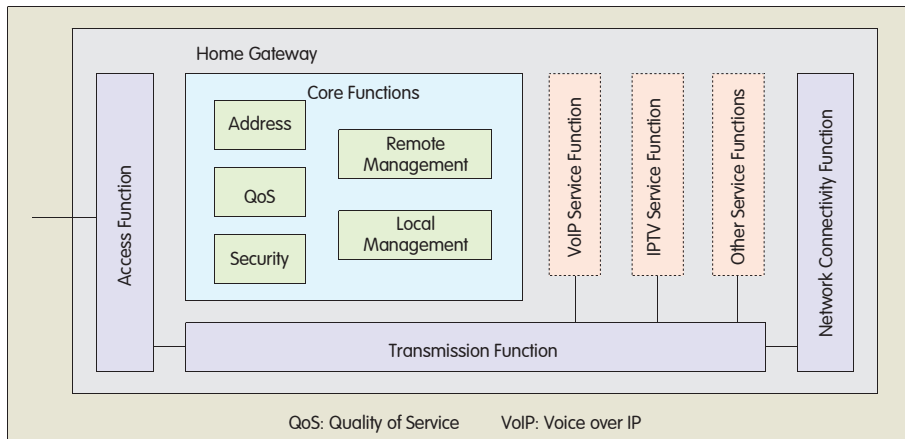
The home gateway may be classified into two types according to the different combination of logical functionality.

- The home gateway without service implementation function (type 1): this type of home gateway only has NAE+HCE function, not supporting service/application-associated functions.

- The home gateway with service implementation function (type 2): this type of home gateway has NAE+HCE+FPE functions. In addition to functions of type 1, it also provides other functions related to service implementation. This type of home gateway may further be classified according to services.

4.2.2 Home Gateway Provided Functions

Generally, a home gateway contains five



▲ Figure 2. Home gateway functions.

functional modules:

- The access functional module: it mainly enables the connection between the home networks and the telecommunications networks.
- The connectivity functional module: it mainly enables the interconnection among end user terminals in the home.
- The transmission functional module: it mainly enables the transmission of IP packets between the home network devices and the telecommunications networks.
- The core functional module: its functions include addressing, QoS, security, remote management, and local management. The address function makes a way for a home gateway to obtain its own IP address and for other in-home terminals to obtain their IP addresses. The QoS function enables multiple-service flow to be processed and forwarded in term of service class. The security function prevents a home network being illegally accessed from any external or internal network. The remote management mainly enables operators to remotely manage and control a home gateway. The local management is responsible for the local login, management, and control of a home gateway.
- The service functional module: it is related to the service implementation of public telecommunications networks. Because of the variety of services, there must be many types of home gateways to support them. Each type of home gateway has special functions to support special services.

Service functional module is optional

and other functional modules are compulsory.

Figure 2 illustrates the classification of home gateway functional modules.

5 CCSA Home Gateway Standardization Plans

5.1 Architecture and Names of CCSA Home Gateway Standards

CCSA is engaged in researching and stipulating home network standards based on telecommunications networks. Its research area is focused on information services provided by public networks.

The recommended architecture of

CCSA home network standards and research topics are depicted in Figure 3. CCSA takes service and application requirements as its main line to carry out the research work on home network standards. The research of service and application requirements lays the foundation for other standards and research topics. Note that services and applications are changeable at different development stages, which will cause the adjustment of research topics.

5.2 Service, Network and Technology Standards, and Research Topics

(1) Service and Application

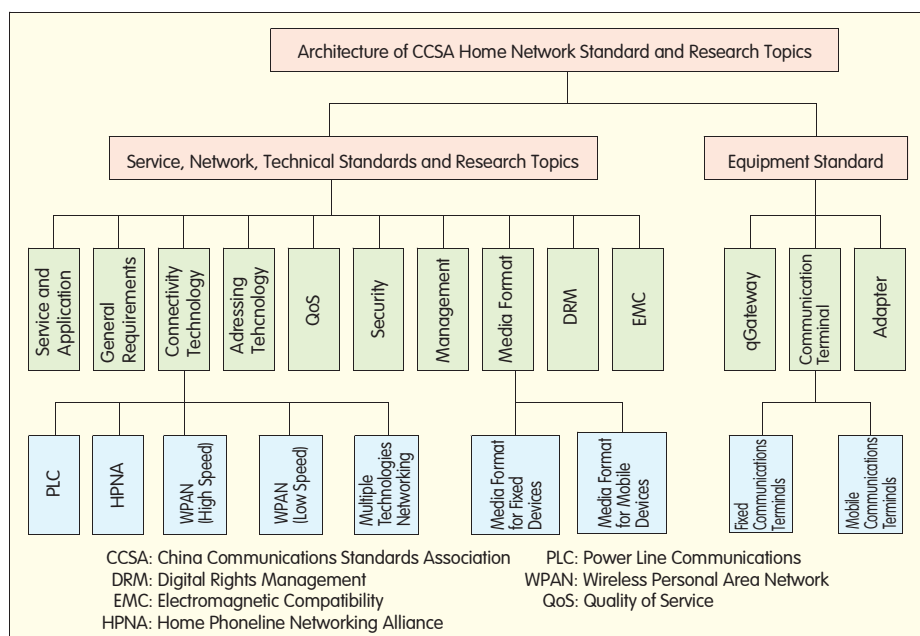
This research topic studies the requirements of service and application, probably provided by operators through a home network, as well as the service flow. There are single service and application, and portfolio of services and applications.

(2) General Requirements

The general research topic covers the architecture, the reference model and the functional requirements of home network, including overall requirements for connectivity, addressing, QoS, security, and management.

(3) The Connectivity Technology

The connectivity technology topic studies physical connectivity technology adopted in the home network, including



▲ Figure 3. CCSA home network standards and research topics.

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Power Line Communication (PLC), Home Phoneline Networking Alliance (HPNA), Wireless Personal Area Network (WPAN) and more. It also studies technical problems caused by the combination of multiple connectivity technologies.

(4) The Addressing Technology

Several topics are covered in the addressing technology research: how to deploy home services on IPv4, how to plan the address of home network devices in the progress of IPv6 evolution and how to implement service interoperability in a mixed IPv4 and IPv6 condition.

(5) QoS

The QoS topic studies technical implementation solutions to guarantee the quality of services when a home network bears and provides multiple services.

(6) Security

The security topic focuses on security problems and technologies related to remote access and control. For example, what measures should be taken to keep in-home devices safe, how to maintain the security of intelligent communication device in the home, and how the entire network withstands attack from the home network.

(7) Management

The management topic studies how a home network device implements the auto-configuration, the remote maintenance, and management of a telecommunication service terminal. Meanwhile, it also deals with the problem when multiple discovery mechanisms co-exist in the home.

(8) Media Format

The media format topic studies the media formats adopted in a home network as well as the interoperability of media formats between multimedia communication services and in-home media.

(9) Digital Rights Management (DRM)

The DRM topic aims at relevant DRM problems and technologies faced by public network operators when they provide audio and video services through a home network. The topic includes how to protect multicast and broadcast contents, how to implement the interoperability between the units in a DRM system.

(10) Electromagnetic Compatibility

(EMC)

The EMC topic focuses on EMC problems faced by home network devices.

5.3 Equipment Standards

Based on that services, networks, and technologies become relatively stable, CCSA will carry out further research on equipment standards such as technical specifications and test methods of gateways, terminals, and adapters.

(1) The Gateway

The gateway technical specifications and test methods should cover the requirements on functions, interfaces, and performance.

(2) The Communications Terminal

The communications terminals refer to those new fixed or mobile terminals that support communications services through a home network. The terminal related technical specifications and test methods should cover the requirements on functions, interfaces, performance, user interfaces and more.

(3) The Adapter

The adapter technical specifications and test methods should cover the requirements on functions, interfaces, and performance. The adapter, located in between a home gateway and a device using private protocols, implements the adaptation function.

Presently, two draft standards have been finished and up for approval: *General Technical Requirements for Home Network Based on Telecommunications Network*, and *Technical Requirements for Home Network Devices Based on Telecommunications Network — Home Gateway*.

6 Development Trends of Home Network Standards

It is clear that home network is still in the pace of development although CE/IT and telecommunications industries have different understanding and their original thoughts of development trends are not the same. However, from the view of development trend, we see two industries actually hold an idea to learn from each other and reach mutual complementary goal. With no doubt, the final development target must be the

same. The final target will be to provide customers with rich and diversified services and applications so that they can enjoy a new, comfortable, convenient and safe life. This target is achieved through two ways: a home network will ensure resources sharing and cooperative work across devices in the home; and a home network will connect to external networks (telecommunications networks/Internet/community area networks) to exchange information.

Therefore, as the concept of home network is developed and deep study is carried out constantly, China's three home network standardization organizations will surely reach the same goal by different routes. Eventually, their standardization research areas will be coincident. In order to strengthen ability of independent innovation in the home network area, speed up the progress of home network standardization, improve the quality of China's proprietary standards as well as worldwide position and influence, the three standardization organizations must break through the industrial barrier, intensify cooperation and make full use of complementary advantages to research China's proprietary home network standards with a win-win attitude.

Manuscript received: 2006-05-09

Biography



Ao Li, senior engineer, is the vice president of the Communications Standard Research Institute, China Academy of Telecommunications Research of MII. He is the vice chairman of the Transport and Access Network Technical Committee of China Communications Standards Association (CCSA), the leader of the access network working group,

and the leader of home network special task group of CCSA. Besides, he is a member of the expert group of ITU-T SG15, and member of telecommunications transport expert consulting group of Telecommunications Science and Technology Commission of MII. He has long been engaged in the research of access networks, customer premise networks and home networks.